Norwegian Meteorological Institute

Application of EMEP/uEMEP for the AAQD review process

Robustness of station exceedance calculations using bias adjustment and station scaling for the 2030 OPT10 emission scenario

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Preface (1)

- Based on emission scenarios provided by IIASA the model system EMEP/uEMEP was implemented to calculate annual mean concentrations at stations sites in the EU27 with a resolution of 25 m.
- Despite the downscaling methodology an underestimation of station concentrations was still found in 2015, with negative biases of -22% and -19% for NO_2 and $PM_{2.5}$ respectively (all stations).
- To provide a more realistic indication of most likely concentrations in future scenarios a bias adjustment, also known as bias correction, was implemented on a per country basis.
- This adjustment was intended to account for any local scale modelling errors and for bias variations between countries in reported emissions

Preface (2)

- In the final report (and the press release from the Commission) in 2022 only maps without bias correction were presented
- These maps showed lower concentration levels than some Member States expected, both for 2020 and for 2030
- Some Member States queried the conclusions drawn on the basis of the impact assessment, if these conclusions were based on these maps.
- However, conclusions were drawn based on both the bias corrected calculations at stations (to understand exceedance risks), and the maps (to understand patterns)
- Bias corrected maps have now been made at high image resolution to provide a better indication of expected future concentrations

What is bias adjustment

- As previously stated, the bias adjustment was intended to account for any local scale modelling errors and for bias variations between countries in reported emissions
- The bias adjustment is a scaling factor per country that scales only contributions from primary emissions within a 40 x 40 km^2 region surrounding each measurement site.
- For NO_2 this region accounted for around 85% of the primary NO_X contributions.
- For $PM_{2.5}$ around 60% of the primary anthropogenic contributions is included in the downscaling that is used in the bias adjustment.
- The bias adjustment implemented did not affect long range transport, secondary particle formation or any non-anthropological sources.
- The bias correction factors for 2015, using 2015 meteorology, were used for all future scenarios including 2020, at that time.

Questions posed

- The question then is if this bias correction is robust and realistic?
- What if 2020 had been used as a basis for the bias correction instead of 2015?
- How does the choice of meteorological year affect the results?
- Are there alternative methods for taking into account the bias in the modelling and do these give similar results?
- Are more recent bias adjusted calculations from the CAO3 studies, after various updates, comparable to those for AAQD?
- Does this in any way change the recommendations?

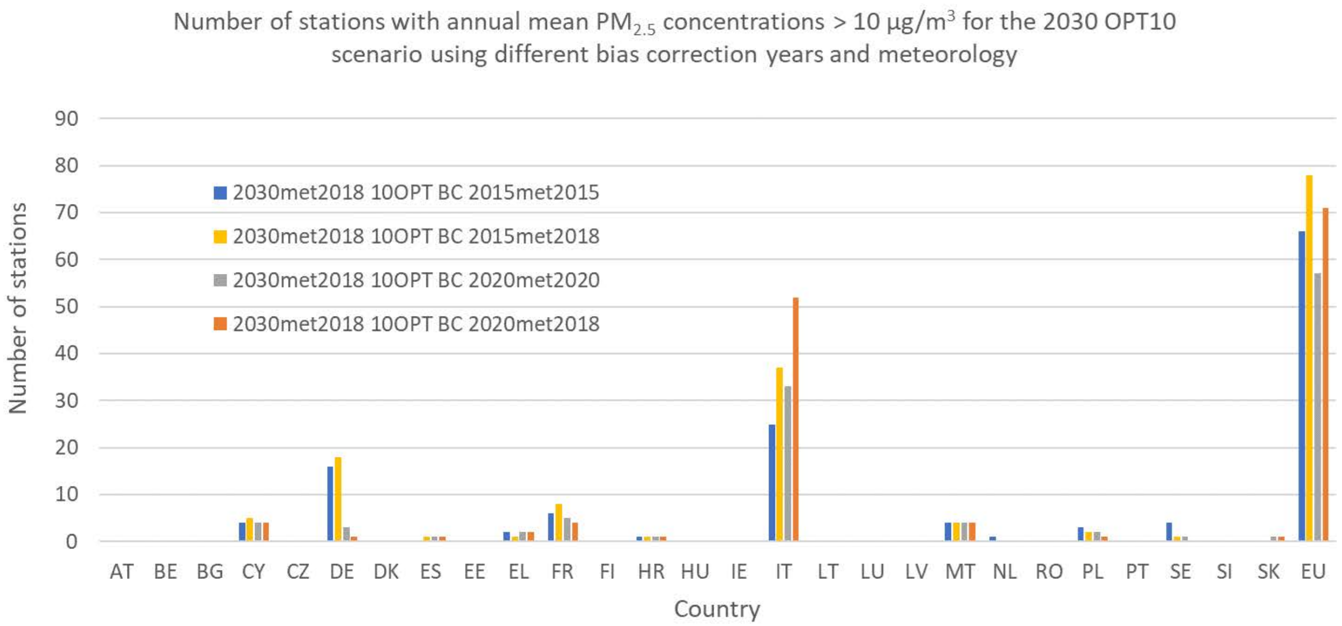
Contents

- Will look primarily at the 2030 OPT10 scenario as this was the scenario on which the commision mainly based their recommendations
  - It is the 2030 scenario optimised in GAINS to achieve $PM_{2.5}$ < 10 µg/m^3 with the minimum of costs
  - This does not mean that 10 µg/m^3 was achieved everywhere as it may not have been technically feasible

- Different meteorological and emission years used for bias adjustment
- Station scaling of observed 2020 concentrations as an alternative method
- CAO3 calculations after model and emission updates
- Mapping

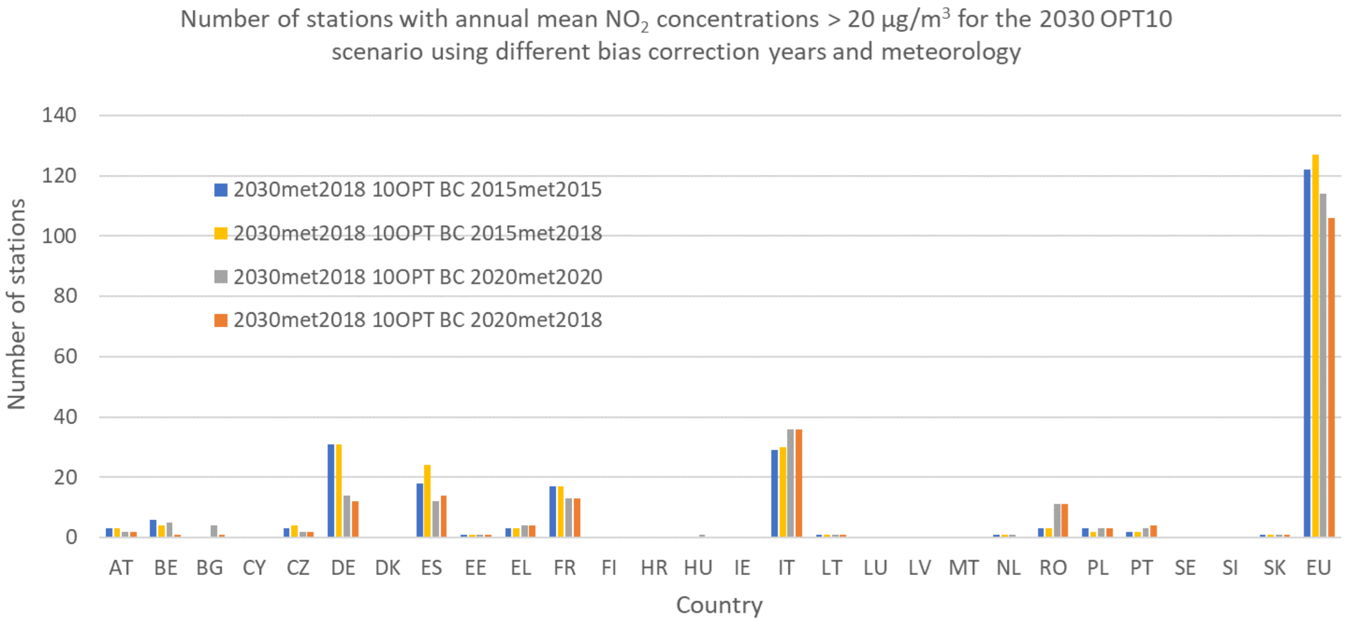
Bias correction applied to the 2030 OPT10 emission scenario for $PM_{2.5}$ based on different meteorological and emission years

- 2015 emissions with 2015 meteorology compared to 2015 observations (2015met2015)
- 2015 emissions with 2018 meteorology compared to 2015 observations (2015met2018)
- 2020 emissions with 2020 meteorology compared to 2020 observations (2020met2020)
- 2020 emissions with 2018 meteorology compared to 2020 observations (2020met2018)



Bias correction applied to the 2030 OPT10 emission scenario for NO_2 based on different meteorological and emission years

- 2015 emissions with 2015 meteorology compared to 2015 observations (2015met2015)
- 2015 emissions with 2018 meteorology compared to 2015 observations (2015met2018)
- 2020 emissions with 2020 meteorology compared to 2020 observations (2020met2020)
- 2020 emissions with 2018 meteorology compared to 2020 observations (2020met2018)



Conclusions from the 2015/2020 bias adjustment and meteorological year assessments?

- The model bias for 2015 and 2020 was very similar. Emission trends from 2015 to 2020 were correctly represented
- The bias adjustment was very similar using either 2015 or 2020 on the European scale but with some larger variability per country
- The meteorological year used made little difference

Estimate of 2030 OPT10 concentrations using station scaling of observed 2020 concentrations

- As an alternative method for estimating station concentrations under the 2030 OPT10 emission scenario the relative change in the modelled concentrations was used to scale the existing 2020 observed concentrations. This calculation can be simply written as:

$$\text{Station(2030 OPT10)} = \text{Station(2020 observed)} \cdot \frac{\text{Modelled(2030 OPT10)}}{\text{Modelled(2020)}}$$

- This is advantageous when looking at individual stations explicitly, as it is based on current measurements
- It is also not dependent on the bias adjustment since the relative difference between the two model calculations are the same with or without the bias adjustment
- Cannot be used for mapping
- These results shown after the next slide

Comparison to CAO3 calculations after model updates for the 2030 OPT10 scenario

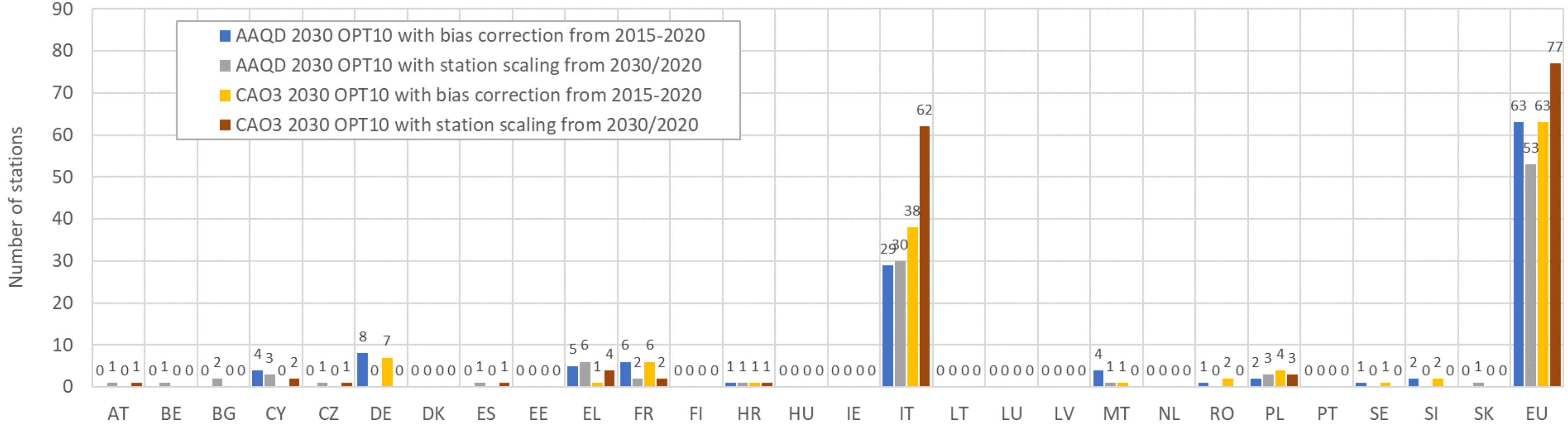
- In 2022 IIASA further developed the emission scenarios used in the AAQD for the Clean Air Outlook for Europe 3 project (CAO3). These new emission scenarios were very similar to those used in the AAQD calculations but were updated after individual country consultations.
- During this period updates to the uEMEP model were also implemented.
- A comparison of the model calculations with observations of both 2015 and 2020 using both CAO3 and AAQD emissions showed similar bias for $PM_{2.5}$ but reduced bias in the model results for NO_2.
- The reduced bias for NO_2 is mostly due to updates in the uEMEP model but also partially due to the changes in the CAO3 emissions.

- The CAO3 calculations represent an updated and alternative estimate of current and future emission scenarios. The question is then if these updates affect the bias corrected results we find for the 2030 OPT10 scenarios?
- As with the AAQD results we determine a bias correction for the 2015 and 2020 CAO3 calculations and then apply this to the 2030 OPT10 calculation for both NO_2 and $PM_{2.5}$. We also apply the station scaling methodology.

$PM_{2.5}$ comparison of bias correction and station scaling using AAQD and CAO3 for the 2030 OPT10 scenario

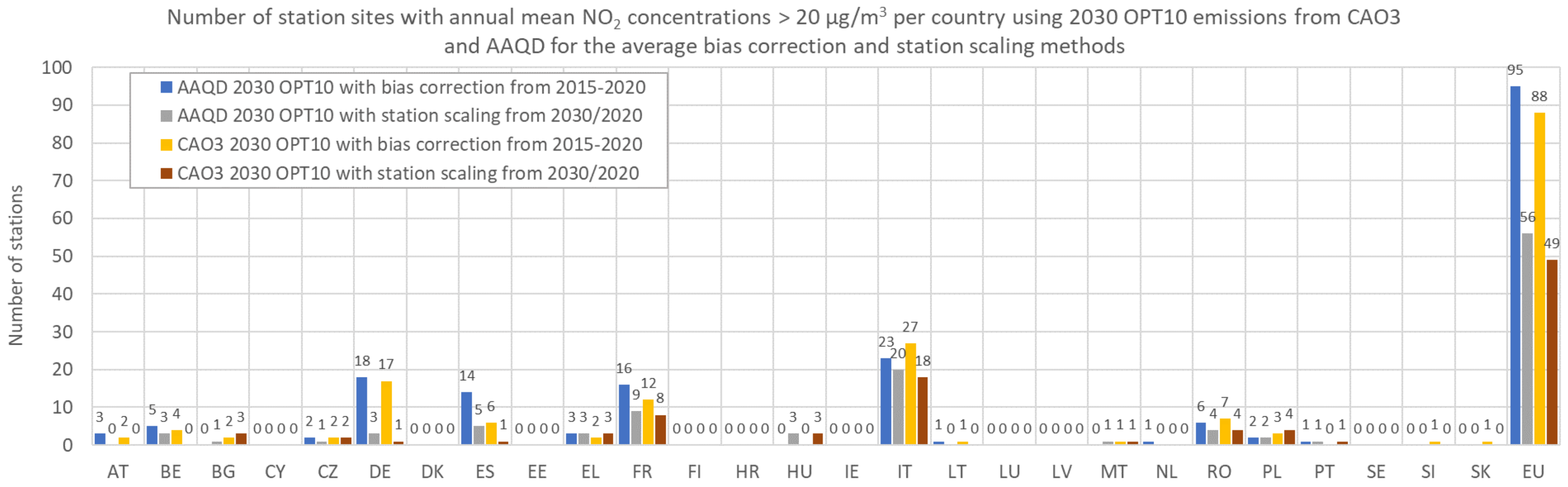
- AAQD 2030 OPT10 with bias correction from average 2015-2020
- AAQD 2030 OPT10 with station scaling from 2030/2020
- CAO3 2030 OPT10 with bias correction from average 2015-2020
- CAO3 2030 OPT10 with station scaling from 2030/2020

Number of station sites with annual mean $PM_{2.5}$ concentrations > 10 µg/m^3 per country using 2030 OPT10 emissions from CAO3 and AAQD for the average bias correction and station scaling methods



NO_2 comparison of bias correction and station scaling using AAQD and CAO3 for the 2030 OPT10 scenario

- AAQD 2030 OPT10 with bias correction from average 2015-2020
- AAQD 2030 OPT10 with station scaling from 2030/2020
- CAO3 2030 OPT10 with bias correction from average 2015-2020
- CAO3 2030 OPT10 with station scaling from 2030/2020



Answers

- The question then is if this bias correction is robust and realistic?
  - It is robust on a European wide scale and for most countries
- What if 2020 had been used as a basis for the bias correction instead of 2015?
  - Same results on the European scale but some variability within some countries
- How does the choice of meteorological year affect the results?
  - Hardly at all
- Are there alternative methods for taking into account the bias in the modelling and do these give similar results?
  - Yes, scaling observations with modelling. Similar results but less stations in exceedance, usually
- Are more recent bias adjusted calculations from the CAO3 studies, after various updates, comparable to the AAQD?
  - Yes
- Does this in any way change the conclusions?
  - Not at the overall EU level (as regards exceedance risks and patterns), but there is regional variability